rieties require a longer time between pollination and the date they reach table condition than do the "flint" sweet varieties; and during this time the former kinds appear to change more of their carbohydrate compounds to starch.

E. M. EAST

CONNECTICUT AGRICULTURAL EXPERIMENT STATION

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE SECTION B—PHYSICS

THE annual meeting of the American Association for the Advancement of Science, Section B, was held in the Physical Laboratory of the Johns Hopkins University, at Baltimore, December 28–31, 1908. This was a joint meeting with the American Physical Society. Each organization held a short session for the transaction of routine business, but the eight sessions for the reading of papers were joint meetings of the two societies.

The presiding officers were Professor Karl E. Guthe, vice-president and chairman of Section B, and Professor Edward L. Nichols, president of the American Physical Society. Professor F. E. Nipher was elected a member of the council, Professor G. F. Hull, of the sectional committee, and Dr. L. A. Bauer, a member of the general committee.

The officers for the next annual meeting, to be held in Boston during the convocation week of 1909–10 are as follows:

Vice-president and Chairman of Section B—Dr. L. A. Bauer.

Retiring Vice-president—Karl E. Guthe.

Members of the Sectional Committee—K. E. Guthe, L. A. Bauer, A. D. Cole, E. L. Nichols, A. Trowbridge, E. B. Rosa, A. P. Carman, G. F. Hull.

In the afternoon of Tuesday, December 29, Professor Dayton C. Miller delivered an address, as retiring chairman of Section B, on "The Influence of the Material of Wind Instruments on the Tone Quality." This has been published in full in SCIENCE, January 29, 1909. It was heard with great interest by a fine audience of about one hundred and fifty. The other seven sessions were attended by from forty to one hundred persons, with an average attendance of about seventy. That on Wednesday forenoon was devoted to subjects of somewhat general interest and papers by Hayford, More and Bauer of the following program were given at that time.

The hotel headquarters for physicists proved a useful and enjoyable feature of the meetings. Hotel Kernan proved a pleasant gathering place and a large proportion of the visiting physicists were registered here. The most successful social event was the subscription dinner for Section B and the Physical Society, held on Tuesday evening at the Country Club. This was attended by about ninety and was generally declared to be the most successful social gathering of American physicists ever held. The success of the occasion was principally due to the care and zeal of Professor J. S. Ames, of Johns Hopkins University.

The titles and abstracts of the fifty-two papers presented at the several joint sessions are given below.

Fatigue of Metals Excited by Röntgen Rays: LOUIS T. MORE and R. E. C. GOWDY, University of Cincinnati.

The work is a continuation of the results previously obtained in the same subject and reported at the Chicago meeting of the American Association for the Advancement of Science (see also *Phil. Mag.*, 1907). A new method has been devised for measuring the secondary radiation given off by metals bombarded by X-rays. Previous results have been confirmed and extended.

To account for the secondary radiation, Professor J. J. Thomson has advanced the theory that the X-rays cause a disintegration of the metal and permit the expulsion of charged corpuscles. Our experiments make this theory doubtful. Iron, lead and copper plates with pure surfaces were used and then the plates were coated with thin films of the lower oxides of the metal and again with films of the higher oxides. The effect of this successive oxidation on the fatigue seems to show that chemical changes of the surface produced by the X-rays with the consequent changes of surface-electrified double layers, will account for the phenomena observed.

Errors in Magnetic Testing of Ring Specimens: M. G. LLOYD, Bureau of Standards, Washington.

This paper is mainly theoretical in character. Formulas are derived connecting the mean magnetizing force with the magnetizing force at the mean radius, and the actual hysteresis loss with the loss which would occur with uniform distribution of flux. Tables and curves illustrate the errors involved and serve to give the necessary corrections in particular cases.

Some Data regarding Recent Magnetic Storms: L. A. Bauer, Carnegie Institution, Washington.

Renewed interest was recently shown in magnetic storms on account of severe ones last August and September and because of Hale's discovery of the Zeeman magnetic effect in sun-spots. Some concluded that a true explanation of the origin of terrestrial magnetic storms had been found. However, a simple calculation shows that the magnetic field intensity observed in sun-spots is totally inadequate to affect the most sensitive magnetic instruments. Whereas the effects actually observed during storms exceed many times—in fact a hundred fold and more—the limit of measurement (about 1/100,000 C.G.S unit). Little progress has been made in the solution of the problems presented by magnetic storms, one reason being that the investigations to be thorough are beyond the power of the average individual. They must, hence, generally be restricted either to one particular phase or to one element—usually the change in the compass direction. An important question is that of the seat of the forces regarded as causing the observed effects; whether it be above the earth's surface or below, or even of combined origin. Another fundamental question is, whether an actual change of magnetization in addition to a shift of the magnetic axis takes place, and if so its magnitude and duration. In the case of the very notable storm of October 31–November 1, 1903, it would appear as though an actual diminution of the earth's magnetic moment occurred which continued almost for two months after the apparent cessation of the storm. Similar calculations are in progress regarding the more recent storms.

Optical Properties of Electrolytic Films of Iron, Nickel and Cobalt: C. A. Skinner and A. Q. Tool, University of Nebraska.

An Absolute Gauge for Measuring High Hydrostatic Pressures: P. W. Bridgman, Harvard University.

The pressure range over which it has been hitherto possible to measure various physical effects of high pressure has been restricted by the fact that the common forms of pressure gauge leak at very high pressures. The best known work in this field has been that of Amagat, who worked to about 3,000 kgm. per sq. cm. This is the working pressure in modern high power artillery. The essential parts of all gauges for these high pressures are a piston fitting a cylinder so accurately that the friction between them is small and at the same time the leak past the piston is very slow. At high values of pressure the leak becomes so rapid that it is impossible to make measurements. In this paper a form of the usual gauge was described in which the cylinder is made to shrink automatically by the pressure, so that the leak remains slight even at very high pressures, while the freedom of motion of the piston is not impaired. With this gauge pressure measurements accurate to .1 per cent. have been made to nearly 7,000 kgm. per sq. cm. At higher pressures other parts of the apparatus break. This is not the limit of the gauge.

The Resistance of Mercury as a Secondary Gauge for High Pressures: P. W. Bridgman, Harvard University.

In practical use the above form of gauge is inconvenient because it is slow and unwieldy. In this second paper measurements of the electrical resistance of mercury under pressure are given from which the pressure may be calculated if the change of resistance is known. Electrical resistance is very easy to measure, and it is proposed that in practise pressure be measured in this indirect way. The accuracy attainable is .1 per cent. The total change of resistance for 7,000 kgm. is about 20 per cent. As one would expect, the change in the resistance effected by pressure is less when pressure is high, as is also the change brought about by temperature change. The change of resistance is about ten times the change of volume produced by a corresponding pressure.

Methods for Measuring Compressibilities at High Pressures: P. W. Bridgman, Harvard University.

In this paper methods were described for measuring the cubic compressibility of solids or of liquids at these high pressures. Measurements were made of several samples of steel, glass and aluminum. The values for steel fall between the two best previous determinations, which differ by 100 per cent. The other values agree with the commonly accepted results. The accuracy of the method is about .35 per cent., considerably higher than the best previous determinations. The only liquid measured was mercury. In only one instance has this been measured before to more than 500 kgm., when measurement was made to 3,000 kgm. The value found in this work agrees with former values, except that the change of

compressibility with pressure seems somewhat less than has been supposed.

An Experimental Determination of the Terminal Velocity of Fall of Small Spheres in Air: JOHN ZELENY and L. W. MCKEEHAN, University of Minnesota.

Stokes's formula for terminal velocity of fall of a sphere in a viscous fluid expresses the result in terms of the acceleration of gravity, the radius of the sphere, the density of the sphere, the density of the fluid and its viscosity. This formula has been used by J. J. Thomson, H. A. Wilson and others in the determination of the charge carried by a gaseous ion.

The velocity of fall of lycopodium, which satisfies Stokes's criterion that the sphere shall be small, was determined experimentally. Variations in the size and density of individual particles were provided against by finding the time of fall, in a wide tube, of a large number of particles in each experiment. The time of fall of the center of gravity of the cloud of particles was assumed to be that of a single particle of average radius and density. The uniformity of the material makes this admissible.

The formula gives velocities, for this particular size, 50 per cent. in excess of those observed. Since this difference depends probably on the size employed, the amount by which the charge on an ion must be increased can not be stated until further experiments are carried out with particles of different sizes.

Note on the Effect of the Phase of Harmonics on Sound Waves: M. G. LLOYD and P. G. AGNEW, Bureau of Standards, Washington.

A harmonic alternator set giving frequencies from 60 to 900 was used to excite a telephone. By choosing a fundamental from one machine and a harmonic from another, and then driving the two generators just out of synchronism, a continuous cyclic change of phase relation occurs. Ordinarily the combined tone sounded by the telephone changes periodically, but these changes are really beats due to the interference of higher harmonics common to the two sources. By connecting the generators three phase, star, and choosing frequencies having a ratio of 3 to 1 or 9 to 1, common impurities are eliminated. When so connected no change in the sound could be detected at low intensities. With louder tones there were cyclic changes which were believed to be due to harmonics introduced by the telephone itself, rather than to an actual dependence of quality upon phase.

Magnetic Double Refraction Normal to the Field in Liquids: C. A. SKINNER, University of Nebraska.

Fourteen different liquids were investigated, including nitrobenzol, nitrotoluol, chlor-benzol, brom-benzol, etc. Twelve of them showed electric double refraction. Each was studied through the spectrum from blue to red (440 to 660). The two effects agree in the law of variation. In carbon bisulphide alone were the electric and the magnetic β of opposite sign.

The Absorption Spectra of Various Potassium and Uranyl Salts: HARRY C. JONES and W. W. STRONG, Johns Hopkins University.

The purpose of this investigation was to find out the nature of the absorbers of the light rays and the effects upon them of external conditions. It is possible in the case of the uranium atom or molecule to make a large number of changes that affect its absorbing power. Salts like the nitrate, sulphate, bromide, acetate and chloride of UO_2 have been used. This gives the effect of the chemical radical on the absorption. Different solvents can be used and various concentrations and the temperature varied. The solution can be placed under great pressure or in a powerful magnetic field. Dehydrating agents like aluminium chloride and sulphuric acid can be added. Some or all of these changes are being made and some interesting results have been found.

A Rowland concave grating is used to give the absorption spectra. Wratten and Wainwright red sensitive films are used for the photographic work. The work is being carried on by a grant from the Carnegie Institution of Washington and is a continuation of the work of Jones and Anderson (Publication No. 110, Carnegie Institution).

Beer's law was found to hold for potassium chromate, potassium dichromate, potassium ferrocyanide and potassium ferricyanide. Concentrated solutions of the uranyl salts do not obey Beer's law.

Uranyl salts show ten absorption bands in the blue-green part of the spectrum. When aluminium chloride is added to uranyl chloride these bands are shifted towards the red. Calcium chloride acts in the same way. Several new bands have been found for the chloride (these are very narrow) which none of the other uranyl salts have so far been found to show.

New Series in the Spectra of Ca, Sr and Ba: F. A. SAUNDERS, Syracuse University.

Photographs of the arc and spark spectra of Ca, Sr and Ba, taken with a quartz spectrograph, show several new ultra-violet lines. In Ca a new spectrum series was found, consisting of reversed single lines, beginning with λ 2398, eight lines in all being observed, five of them new. In Sr a similar series exists, seven lines having been observed. In Ba there are evidences of the same sort of thing. Series of *pairs* have been known for some time to exist in these spectra; few of the lines, however, having been picked up. Four new pairs were found in Ba and two in Sr, which help to fill out the two "subordinate" pair series in each of these elements. Formulæ which represent these series were calculated out, as was also done in the case of the series first mentioned.

Ionization in Closed Vessels: W. W. Strong, Johns Hopkins University.

The purpose of these experiments is to find what the nature of the external radiations are, that produce part of the ionization in closed vessels. In order to do this it is necessary to use a vessel in which the ionization produced by the walls of the vessel itself is constant. This ionization can be easily found by putting the vessel within a thick screen of metal or water so that all external radiations are absorbed.

Electroscopes were used for this work and the ionization of the enclosed gas was measured by means of the rate of leak of the electricity from the gold-leaves suspended inside the electroscope. The charged system inside the electroscope could be charged from the outside by means of a small spark gap. The electroscope was, therefore, air-tight and everything inside the vessel remained the same unless affected by radiations that could pass through the walls of the electroscope.

By letting the electroscope into a large cistern it was surrounded by a screen of water at least four feet thick. This was done with an electroscope September, 1907 (*Phys. Rev.*, p. 44, July, 1908). The same electroscope was placed in the same cistern, July, 1908. (Readings of the electroscope were here given.)

These readings show that the natural ionization within the vessel had remained practically constant throughout almost a year.

The same electroscope (and others in a like manner) when placed outside of buildings showed very marked increase in its rate of leak during the day. This, therefore, must be due to some external radiation that was screened off by the water in the cistern. (Screens of lead and iron were also used.) Care was taken to keep the temperature of the electroscope constant.

Velocity of the Negative Ions Produced by the Ultra-violet Rays in Various Gases at Different Pressures and Temperatures: Alois F. Kovárík, University of Minnesota.

The object of this investigation is the study of the structure of the negative ion. For this purpose the velocity is measured at different pressures and at different temperatures. The method used is that of an alternating field. In the case of air the product of the velocity by the pressure is nearly constant between the pressures 760 mm. and 200 mm., but at 100 mm. this product increases by 25 per cent., at 60 mm. by 65 per cent. and at 4.3 mm. by 200 per cent. above the value at 760 mm. In the case of CO_2 the product changes a little more rapidly. The velocity of the negative ions in dry air at 760 mm. and 0° C. is 2.05 cm. per second for a gradient of 1 volt per centimeter, and in dry CO_2 at ordinary conditions of pressure and temperature, the velocity is about 1.02 cm. per sec.

Preliminary experiments with change of temperature were made in air and up to 400° C. the velocity was found to vary inversely as the density of air. These experiments are being continued.

Momentum Effects in Electrical Discharge: F. E. Nipher, Washington University.

An electrical discharge is sent around a right angle in a wire. Spark discharge passes from machine to earth in either the positive or negative line.

A very marked difference between the positive and the negative discharge is found. A decided difference between the effects on the photographic plate is found on the two sides of the angle. The negative discharge is the active one in both lines. An account of these experimental results is given in Science for December 4, 1908. The actual effects were shown by means of a large number of lantern slides.

Electrical Stimulation of Plant Growth: Amon B. Plowman, Beaver, Pa.

Experiments and observations extending through a period of more than ten years, indicate rather conclusively that electrical charges of positive sign more or less completely inhibit the vital processes of plant protoplasm through which such charges are caused to pass; while, within a rather wide range of conditions, negative electrical charges stimulate such processes, sometimes to a quite remarkable degree.

Most of the striking results of electro-culture, including those recently obtained by Sir Oliver Lodge, are quite readily accounted for, if the above conclusions are correct.

This paper was illustrated by means of several photomicrographic and other lantern slides.

Note on the Kathode Equilibrium of the Weston Cell: F. A. WOLFF, Bureau of Standards, Washington.

The Theory of Coupled Circuits: LOUIS COHEN, Bureau of Standards, Washington.

It is a well known phenomenon that when two electrical circuits are coupled together either electromagnetically or direct, two distinct oscillations will be produced in either circuit, and there will also be two distinct damping factors. The problem was the subject of several important papers by several eminent German physicists, but there are certain mathematical difficulties inherent in the problem, which made it difficult to get the complete solution, and all previous investigators limited themselves to some form of approximation.

In this paper an entirely different method of mathematical treatment was adopted and which made it possible to obtain an exact solution. The paper being of a mathematical nature it is rather difficult to give an outline of the work in an abstract. The results are as follows: If we denote by V_1 and V_2 the potentials in the primary and secondary circuits, we have

$$V_1 = \{H_1 e^{-\alpha_1 t} + H_3 e^{-\alpha_2 t}\} \cos \lambda_1 t + \{H_2 e^{-\alpha_1 t} + H_4 e^{-\alpha_2 t}\} \cos \lambda_2 t,$$

$$V_2 = H_5\{e^{-\alpha_1 t} + e^{-\alpha_2 t}\} \cos \lambda_1 t + H_6\{e^{-\alpha_1 t} + e^{-\alpha_2 t}\} \cos \lambda_2 t,$$

α_1 and α_2 are the damping factors, λ_1 and λ_2 are the frequency constants and they have been completely determined.

Photographic Registration of Sounds: DAYTON C. MILLER, Case School of Applied Science, Cleveland.

For making large scale records, showing the details accurately, of complex sound waves having frequencies ranging from 500 to 10,000, the phonograph and oscillograph methods seem unsuitable. The following direct mechanical method has given satisfactory results.

A small steel cylinder, 1 mm. in diameter, is arranged to receive angular motion with a minimum of reaction effects, which is proportional to the displacement of a sensitive diaphragm. A minute mirror, with its plane in the axis of the cylinder, reflects light to a special camera, and at a distance of 30 cm. gives waves 15 cm. wide which show great detail. Long strips of photographic films were shown and projected by the lantern, showing with great clearness and in full detail the record of overtones, intensity variation, etc., of various spoken phrases. (The words "physical laboratory" received careful and interested attention from the audience.)

The Thermodynamics of Saturated Vapors: J. E. SIEBEL, Chicago, Ill. (Read by title.)

The object of this paper is to demonstrate the necessity of an investigation as to whether certain hypothetical concepts in the theories of thermodynamics and which find their most general expression in the assumption of a universal identical zero of energy (—273° Cels.) and a supposed universally irretrievable dissipation of energy are equally applicable to the thermodynamics of saturated vapors as they appear to be to the thermodynamics of permanent gases.

The Heat Balance in Thermoelectric Batteries: J. E. SIEBEL, Chicago, Ill. (Read by title.)

The author attempts to show that the heat and electricity exchanged in thermoelectric elements are functions of temperature, specific heat and conductivity and produces a formula and calculations made thereby, the results of which latter conform apparently well with a number of experimental results obtained by other observers.

The Effect of the Magnetic Impurities in the Copper Coils of Moving Coil Galvanometers upon their Sensitiveness, Hysteresis and Zero Shift: ANTHONY ZELENY, University of Minnesota.

The magnitude of the effect due to the magnetic impurities in the copper coils upon the sensitiveness of a moving coil galvanometer was determined by obtaining the period of vibration of the coil system in and out of a magnetic field.

If M represents the moment, per unit angle of displacement of the coil, due to the magnetic impurities; T, the torsional moment; and t_1 and t, the periods of vibration of the system when the coil is within and outside of the magnetic field; then

$$M/T = (t^2 - t_1^2)/t_1^2.$$

The value of the galvanometer constant is increased due to the magnetic impurities by the factor $(1 + M/T)$.

The values of M/T were determined for several galvanometer coils in fields of various strengths produced by an electromagnet. The values, when using a 1.5 mil phosphor-bronze strip for the upper suspension, varied for different coils from

0.82 to 1.31, in a field whose intensity was 400 units, which is the intensity usually found in ordinary galvanometer fields.

By plotting the relation between M/T and the field strength when the values of the latter were both increasing and decreasing, a marked hysteresis was found, which explain the hysteresis observed in galvanometer deflections whose magnitude depends somewhat on the direction from which the coil comes to its deflected position.

The relation between the strength of the magnetic field and the "set in the fiber" obtained after a reversed deflection was found to be proportional to the strength of the field, except that in weak fields there was no observable set. This shows, as previously explained by the writer, that the set is practically all due to a change in the strength and the direction of magnetization of the impurities in the coil. This magnetization gradually returning to its normal strength and direction explains also, in part at least, the shifting of the zero point with time.

The Three Temperature Coefficients of the Moving Coil Galvanometer and their Relation to the Temperature Coefficients of its Various Parts: ANTHONY ZELENY and O. HOVDA, University of Minnesota.

The values of the temperature coefficients for galvanometers having chilled cast-iron magnets are given in the following table, where B is the temperature coefficient of a particular circuit.

Measurement	Suspension	Coefficient
Current,	Phos. bronze,	$+0.00018$
	Steel,	$+0.00005$
Potential,	Phos. bronze,	$+0.00018-B$
	Steel,	$+0.00005-B$
Ballistic,	Phos. bronze,	-0.00017
	Steel,	-0.00017

The temperature coefficient for current measurements is shown to be

$$d_k' = F_k + t_k + L_k - D_k, \qquad (1)$$

where d_k', F_k, t_k, L_k, D_k, are the temperature coefficients respectively for deflections, field strength, period of vibration of the coil, and the linear expansion of cast iron and of copper.

The temperature coefficient for potential measurements can be calculated from

$$d_k'' = d_k' - B, \qquad (2)$$

where B, as given above, is the temperature coefficient for the resistance of a particular circuit.

The temperature coefficient for ballistic throws is

$$d_k = d_k' - t_k. \qquad (3)$$

These equations enable any one of the three temperature coefficients to be calculated from the known temperature coefficients of the various parts of the galvanometer.

The temperature coefficients of a galvanometer with a magnet other than chilled cast iron can be calculated from

$$K' = K + (F_k' + 0.00040), \qquad (4)$$

where K represents the value of any particular coefficient given in the above table, corresponding to the one desired, and F_k' is the temperature coefficient of the field strength for the magnet of the galvanometer whose temperature coefficient is to be determined.

A New Method for the Absolute Measurement of Resistance: E. B. ROSA, Bureau of Standards, Washington.

A Plea for Terrestrial and Cosmical Physics: L. A. BAUER, Carnegie Institution, Washington. This paper will be published in full in SCIENCE.

The Ellipticity of the Earth is Not a Proof of a Former Liquid State: JOHN F. HAYFORD, Coast and Geodetic Survey, Washington.

The idea is often expressed, even by physicists of high rank, that the observed ellipticity of the earth is a proof of a former liquid state. This idea is based upon a gross misconception of the magnitude of the stresses which would be produced within the earth by any departure of the actual ellipticity from the value corresponding to the rate of rotation. Sir George Darwin has computed that a departure of only one seventh part, of the actual ellipticity from that corresponding to the rotation, would produce stress-differences in the interior of the earth as great as five tons per square inch. Even the best granite will ordinarily fail under a stress-difference less than five tons per square inch. Therefore, unless the earth in its inner parts is stronger than the best granite it will yield to the stresses and take a new shape before the actual ellipticity has departed from that due to the rotation by as much as one seventh part.

Any one who will start from this as a basis and consider the improbability of the earth being as strong as the best granite throughout, even if it is solid, consider the improbability of the material in the earth being incompressible under stresses applied continuously for ages, and consider the uncertainty introduced into the evaluation of the theoretical ellipticity due to rotation on account of this evaluation being affected by the assumed relation of depth and

density, he will reach the conclusion that the present apparently close agreement between the observed ellipticity and the theoretical ellipticity due to rotation is not a proof of a former liquid state.

He will conclude that it is merely an indication of the strength of the material in the interior of the earth, and that the evidence is far from being sufficient to prove that the strength of the material in the interior, available to resist stress-differences, is now or ever has been so small as to justify the statement that the material is or has been a liquid.

Atomic Theories: L. T. MORE, University of Cincinnati.

An Electrical Method for Determining the Amount of Moisture in Grain and Other Materials:[1] ANTHONY ZELENY, University of Minnesota.

Two plates or pointed conductors made of dissimilar metals are inserted into the material in which it is desired to know the amount or percentage of moisture. These plates or points form the electrodes and the moisture the electrolyte of a voltaic battery which causes a current to flow through the galvanometer, whose magnitude depends on the amount of the moisture.

The size of the scale divisions representing any definite amount of moisture is first determined experimentally for each particular kind of material. When the temperature of the material under test influences the magnitude of the deflection, a proper galvanometer shunt is used with its lugs labeled in degrees, so that, when set to indicate the temperature of the material, the proper values for the amount of moisture are obtained regardless of the temperature.

In the case of corn, it was found desirable to have the two dissimilar metals of copper and zinc in the form of points which are pressed into the germ of the individual kernel. The deflection obtained indicates directly the percentage of moisture in the whole kernel. A curve exhibiting the relation between the deflection and the percentage of moisture was shown.

This apparatus is found to be capable of giving values accurate to about 0.1 per cent.

On the Extra Transmission of Electric Waves: F. C. BLAKE, Ohio State University.

With the same apparatus that Blake and Fountain (*Phys. Rev.*, XXIII., p. 257, 1906) used, the conditions insisted upon by Dr. Schaefer (*Phys. Rev.*, XXIV., p. 421, 1907) were fulfilled. Two diaphragms, 2.5 meters square and of aperture 24 by 32 cm., were inserted, one near the vibrator mirror, the other near the receiver mirror with the resonator system between them. Nine per cent. of *extra transmission* was found, using long strips 3 cm. apart on plate glass. Afterward only a single diaphragm was used, it being placed as near as possible to the receiver mirror. Its aperture was 68.5 cm. long and of a width that was varied from 8 to 61 cm. The *extra transmission* was 15 per cent. in amount and independent of the width of the diaphragm aperture.

Taking this last value as a true measure of the extra transmission it would appear that the use of diaphragms, especially when their apertures are as small as Schaefer demands, introduces errors due to diffraction, but in no case does it completely mask the effect of extra transmission.

Then the vibrator was varied by short steps a distance of 1 cm. either way from its usual focal position of 7.5 cm., a single diaphragm of aperture 68.5 by 16 cm. being used near the receiver mirror. No change in the extra transmission was obtained, although these vibrator changes changed the beam from one quite strongly divergent to a convergent beam.

Entladungsstrahlen: ELIZABETH R. LAIRD, Mount Holyoke College.

A Spectrometer for Electromagnetic Radiation: A. D. COLE, Ohio State University.

The continuation of work on diffraction of electric waves, on which a partial report was given at the New York meeting of the American Association for the Advancement of Science, made it desirable to have a more convenient means of quickly changing the angle between the direction of wave propagation and the line connecting the diffraction edge or slit with the receiver. This resulted in a mounting for the several parts of the apparatus similar to that of the parts of a working spectrometer for light radiation.

It seemed worth while to develop the design still farther, so that the apparatus might later be used by advanced students as a more convenient means of repeating the classical experiments of Hertz, Boltzmann and Righi. The use of the conventional spectrometer design serves to strengthen the force of the analogy between electrical and light radiation, particularly when used for lecture demonstrations, for which it is well adapted. Drawings of the apparatus with a considerable variety of accessories for special uses, were shown and described. By a few simple

[1] Patent pending.

changes and adjustments it is easily and quickly adapted for use as an optical bench or as an interferometer for electromagnetic radiation. The wave-lengths preferred are from 10 to 15 cm., the parabolic mirrors of 35 cm. aperture, lenses and prism 22 cm. high, prism-table 26 cm. diameter, and the length over all 225 cm. It is made of oak, and provided with four graduated circles for reading the angles through which different parts of the apparatus are rotated when in use.

A Method of Determining the Electrode Potentials of the Alkali Metals: Gilbert N. Lewis and Charles A. Kraus, Massachusetts Institute of Technology.

The electrode potentials of the metals of the alkalies and the alkaline earths, notwithstanding their great importance, have never been determined, because of the extreme reactivity of these metals. The method now adopted, which has proved entirely successful in the case of the sodium electrode, consists in measuring the electromotive force between the metal and its dilute amalgam in mercury, with an electrolyte consisting of a solution of a salt of the metal in liquid ethyl amine. The electromotive force so obtained can readily be shown to be independent of the electrolyte and the solvent. It is, therefore, the same as would be obtained if the electromotive force between the metal and amalgam could be measured in an aqueous solution. The potential of the amalgam, against a normal aqueous solution of a salt of the metal may with certain precautions be measured directly against a normal electrode. Adding the electromotive force so obtained to the electromotive force between the metal and amalgam gives directly the potential of the metal in a normal solution of its ion in water (potential of the normal electrode taken as zero). In the case of sodium, this method has made it possible to determine the electrode potential within a few tenths of a millivolt. The value obtained is about half a volt higher than that which has been previously assumed for the sodium electrode.

Non-Newtonian Mechanics and the Principle of Relativity: Gilbert N. Lewis and Richard C. Tolman, Massachusetts Institute of Technology.

The laws of non-Newtonian mechanics previously derived by one of the authors from the fundamental conservation laws and from a simple assumption in regard to the nature of light are identical with those which Einstein has obtained from the principle of relativity and the laws of electro-dynamics. In this paper it is shown that the same equations may be obtained without the aid of the electro-magnetic theory from the principle of relativity and the conservation laws.

On the Influence of Temperature and Transverse Magnetization upon the Resistance of Bismuth and Nickel: F. C. Blake, Ohio State University.

The resistance of nickel and bismuth was investigated over a range of temperature from $-192°$ C. to $+183°$ C., and for all field-strengths between 0 and 36.6 kilogauss. For measuring temperature flat spirals of fine platinum wire were attached to the mica supports of the bismuth and nickel spirals. The apparatus was that previously used by duBois and Wills (*Verh. d. D. Phys. Ges.*, I., p. 169, 1899).

At liquid air temperatures no such high values of the resistance of bismuth were obtained as had been obtained by Dewar and Fleming and by duBois and Wills. Instead, a maximum of resistance was found between $-160°$ and $-180°$ C. for fields greater than 30 kilogauss. The higher the field the higher the temperature at which this maximum appeared.

If R' is the resistance in the field H at the temperature T, and R_0 the resistance without the field at 0° C., then $R'/R_0 = f(T, H)$. A set of isothermal curves, $R'/R_0 = f(H)$ and another set of isopedal curves, $R'/R_0 = f(T)$ were experimentally determined.

For nickel a set of isothermal curves, $(R' - R)/R_0 = f(H)$, where R is the resistance of the nickel out of the field at temperature T. For all temperatures investigated the fraction $(R' - R)/R_0$ was negative for fields greater than 2,500 gauss, and its value was greater for the higher temperatures. For fields greater than 10 kilogauss it increased with increasing field except at liquid air temperatures; at $-190°$ C. it was a maximum at 8 kilogauss, decreasing slowly for higher fields. For fields less than 2,500 gauss this fraction was positive and it was thought that part or all of this increase in resistance for low fields could be explained by longitudinal magnetization, whose presence could not be wholly avoided.

A New Form of Standard Resistance: Edward B. Rosa, Bureau of Standards, Washington.

The new form of resistance standard, which has been developed at the Bureau of Standards during the past two years, differs from the Reichsanstalt form in being smaller and having the resistance coil sealed air tight in a case that is filled with pure oil, insuring protection for the resistance

coil from the effects of atmospheric moisture, reduces the danger of oxidation due to imperfect covering of shellac, and protects the coil from mechanical injury. The resistances when properly prepared and mounted and protected in this manner, remain remarkably constant in value, whereas open coils in oil almost invariably have a higher resistance in summer than in winter, and fluctuate more or less in value from time to time with the weather. As a result of the discovery of the effect of atmospheric humidity on the resistance of standards made at the Bureau of Standards, the National Physical Laboratory of England has sealed its standards, and the German Reichsanstalt is keeping its standards in a chamber at a constant humidity. The use of the new sealed resistances at the Bureau of Standards has increased the accuracy of resistance work appreciably.

A Proposed Modification of the Kirchhoff Method for the Absolute Measurement of Resistance: FRANK WENNER, Bureau of Standards, Washington.

An Instrument Designed for More Precise Determination of Magnetic Declination at Sea: WILLIAM J. PETERS, Department Terrestrial Magnetism, Washington.

The cruises of the *Galilee* in the Pacific Ocean, among other results, made very apparent the necessity of more accurate determinations of magnetic declination than could be made with the ordinary instruments of navigation. A collimating instrument has been constructed by Mr. A. Widmer, mechanician of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, which will be used in experimental work on the vessels now being built for a magnetic survey of the ocean areas. Experiments were made on the last cruise of the *Galilee* which assured the practicability of using such an instrument and indicated the possibility of a high order of accuracy.

Many parts of the Ritchie ten-inch liquid compass were used. The card was altered to a four direction collimator by the addition of four concave mirrors with a scale of seven divisions in the focus of each. This alteration increased the original mass by one twentieth part, but decreased the radius of gyration. The period of the collimator arrangement in liquid is now about eleven seconds at Washington. The angle between a collimator axis and a celestial body is measured by a pocket sextant, the scale being viewed through windows in the bowl. The instrument is not intended for a navigation instrument, but as a step in the attainment of the highest precision in determinations of magnetic elements at sea.

(The paper will be printed in full in the March number of *Terrestrial Magnetism and Atmospheric Electricity.*)

The Electrical Conductivity of the Atmosphere Over the Pacific Ocean: PAUL H. DIKE, Carnegie Institution, Washington.

The work described was done on board the Magnetic Survey Yacht *Galilee* during the cruise of 1907–08. The purpose was to obtain data as to the earth-air current at sea, to compare with similar results obtained on land. The method involves the measurement of two quantities, the specific conductivity of the air and the vertical potential gradient. The latter measurement was found to be impracticable on board ship, and only a few values were obtained, during a calm. These were of the same order of magnitude as are ordinarily observed on land. The specific conductivity of the air was measured by means of the Gerdien apparatus, consisting of a cylindrical condenser, the inner cylinder of which is connected with an electroscope. The conductivity of the air is computed from the rate of dispersion of a charge put upon the inner cylinder when a uniform current of air is drawn through the apparatus. The reading of the electroscope offered the principal difficulty.

The mean values of the conductivity from all the observations of the voyage were as follows:

$$\lambda_p = 1.603 \times 10^{-4} \text{ electrostatic units.}$$
$$\lambda_n = 1.433 \times 10^{-4} \quad " \quad "$$
$$\lambda_p/\lambda_n = 1.12$$

Assuming a potential gradient of 100 volts-meter these values of conductivity give a vertical earth-air current 3×10^{-16} amperes per square centimeter of the earth's surface, slightly larger than the usual value on land. No variation with latitude was discernible, though the observations extended from 65° 41′ north to 45° 07′ south.

Ultra-violet Absorption and Fluorescence and the Complete Balmer Series of Sodium Vapor: R. W. WOOD, Johns Hopkins University.

The absorption spectrum of dense sodium vapor, contained in a steel tube one meter in length, provided with quartz windows and heated red hot in a combustion furnace, shows the lines of the principal series (Balmer formula) reversed. But seven lines of this series have been previously observed, the observations having been confined to the emission spectrum.

Employing a small quartz spectrograph by Fuess (focus 15 cm.) 24 lines were found and measured and indications of the "head" of the series appeared in the plate though it was not resolved into lines.

With the large quartz spectrograph of the Bureau of Standards 48 lines were resolved, bringing us within 0.1 of an Angstrom unit of the theoretical head of the band. The largest number of lines forming a Balmer series ever observed in the laboratory is twelve in the case of hydrogen (Cornu and Ames). Solar hydrogen (chromosphere) shows 29 lines. The sodium series is 19 ahead of any Balmer series ever observed, even in celestial sources. These ultra-violet lines are accompanied on each side by a channelled spectrum, analogous to the channelled spectra observed in the vicinity of the *D* lines, which form the first member of the Balmer series.

It is in the region of the channelled spectra that the interesting results in the fluorescence of the vapor previously described were found. An attempt was accordingly made to ascertain if the ultra-violet channelled spectra exhibited the same phenomena. Such was found to be the case. Exciting the vapor with the zinc spark, a strong fluorescence was found to be stimulated by the zinc triplet at 3344–3302.

Results of Some Recent Intercomparisons of Magnetic Standards by the Carnegie Institution of Washington: J. A. Fleming, Carnegie Institution, Washington.

One important detail of the magnetic survey of the globe undertaken by the Department of Terrestrial Magnetism of the Carnegie Institution of Washington is that of the correlation of the observatory standards of various governments and institutions. Comparisons have already been made at seventeen observatories in various parts of the world; the results of the four most recent intercomparisons were discussed in detail in the paper and may be summarized thus: The following corrections should be applied to the provisional standards of the Department of Terrestrial Magnetism of the Carnegie Institution. The probable errors of mean differences are given with them. For Kew Observatory; declination $+ 0'.6 \pm 0'.15$, horizontal intensity $-0.0001H \pm .00005H$, inclination $-2'.6 \pm 0'.1$. For Helwan; dec. $+ 0'.5 \pm 0'.1$, hor. intens. $+ 0.0004H \pm .00004H$, inclin. $+ 0'.1 \pm 0'.1$. For Tiflis; dec. $+ 0'.7$, hor. inten. $+ .0006H \pm 0.00006H$, inclin. $- 1'.7 \pm 0'.1$. For Christchurch; dec. $+ 1'.5 \pm 0.04$, hor. inten. $+ 0.0006H \pm .00006H$, inclin. $- 1'.2 \pm 0.3$.

The values are to be applied algebraically, east declinations, north inclinations and horizontal intensities being considered positive, and west declinations and south inclinations, negative. The preliminary "International Magnetic Standard" for horizontal intensity is confirmed in view of the accordance of the correction at Kew with the indications of Watson's determinations of the earth's field in international units.

A Critical Review of the Problem of Pressure in the Kinetic Theory of Gases: Luigi d'Auria, Philadelphia, Pa.

This paper seeks to show that the recognized method of solution of this problem is erroneous and the gaseous pressure per unit area is equal to the energy of agitation of the gas per unit volume. It will be printed in *Popular Astronomy.*

The Dynamophone: J. Burkett Webb, Stevens Institute of Technology.

Some years ago the problem arose of measuring the power which a turbine transmitted through its shaft to the propeller. The ordinary "indicator" being useless, a method depending on the torsion of the shaft was invented. As it was the intention to protect it by patent, it could not be published sooner, but it has leaked out somewhat and more or less incorrect references to it have appeared in German papers.

The first idea was to measure the torque optically, but a better method was adopted. The apparatus necessitates no mechanical contact with the shaft and the speed can also be observed without the usual speed counter. The degree of accuracy is very high, there being no difficulty in making single observations within one per cent. of error.

The apparatus consists of two toothed iron rings which are fixed permanently to the flanges of the shaft at as great a distance apart as possible. Opposite these rings on a frame fast to the floor are mounted telephone magnets adjustable radially and concentrically as to the shaft axis. Each ring and magnet (or pair of magnets) constitutes an alternating dynamo whose current intensity can be regulated by the radial adjustment of its magnet and whose phase can be varied by the concentric movement, and these two dynamos are connected in series so that when the shaft is not twisted their phases are opposite and neutralize each other in a receiver inserted in the circuit. When, however, the shaft twists the phases become different and a clear tone is perceived.

To measure the torque one of the concentric adjustments is then made until the tone disappears and the angular change read on a scale graduated preferably to horsepower per revolution. The pitch of the tone compared with a calibrated tuning fork gives the speed. The necessary calibration of the shaft is made before it is placed in position or it can be made afterward. (A model was shown.)

Some Optical Effects of Changes in Ether Density: CHARLES F. BRUSH, Cleveland, Ohio. (Read by title.)

The Lumeter, a Practical Measure of General Luminosity: HENRY E. WETHERILL, M.D., Philadelphia. (Read by title.)

A Ballistic Dynamometer Method of Measuring Hysteresis Loss in Iron: MARTIN E. RICE and BURTON MCCOLLUM, University of Kansas. (Read by title.)

The sample to be tested, which should be laminated, is wound with a primary coil and a test coil. The latter is connected in series with the fine wire movable coil of a dynamometer and the former in a series with the coarse wire-fixed coil of the dynamometer. When the primary current is reversed, the dynamometer measures by its ballistic deflection the total energy loss per half cycle in the iron and in the test coil circuit. Since the hysteresis loss is independent of the period of the cycle while all the other losses measured are inversely proportional to the period of the cycle, it is easily possible by the insertion of a choke coil in the primary circuit and the use of a moderately high resistance test coil circuit to keep these other losses below one per cent. of the total loss measured. A comparatively rough estimate of these other losses is then sufficient to enable the true hysteresis loss to be determined with an error of only a small fraction of one per cent.

The dynamometer can be calibrated by discharging a condenser or a mutual inductance through its movable coil while a constant current is maintained in its fixed coil.

This method eliminates the difficulties inherent in the wattmeter methods due to uncertainties in frequency and wave shape while it avoids the tedious process of taking a long series of readings, plotting a curve and measuring its area, as in the ballistic galvanometer methods. Tests can be made much more rapidly than by the wattmeter methods, while the results obtained are fully as accurate as by the ballistic galvanometer methods.

On the Diurnal Variations in the Intensity of the Penetrating Radiation Present at the Surface of the Earth: G. A. CLINE, Toronto University.

On the Character of the Radiation from Potassium: J. C. MCLENNAN, Toronto University.

The Action of Electrolytes on Copper Colloidal Solution: E. F. BURTON, Toronto University.

The experiments detailed in the present communication are a continuation of those performed by the writer on the action of small traces of electrolytes on silver and gold colloidal solutions prepared by Bredig's method. With these solutions the particles in the pure solution are negatively charged and it was found that, if an electrolyte was added, the positively charged ion was the potent one in reducing the velocity with which the particle moved in a given electric field; *i. e.*, the ion charged oppositely to the colloidal particle produces the discharge of the particle and consequently coagulation of the colloid.

Copper colloidal solutions were chosen on which to work because they have positively charged particles in the pure solution. The electrolytes used were solutions of potassium chloride, potassium sulphate, aluminium sulphate, potassium phosphate, potassium ferricyanide. With this series it was possible to compare the effect of the monovalent and the trivalent ions of both acids and bases.

Every electrolyte added produced a decrease of the velocity with which the copper particles moved to the cathode. It is the ion bearing the negative charge which is active in reducing the velocity. This power of the negative ion depends on the valency in a way analogous to the relations found by Picton and Linder, and Hardy for the coagulative power of ions. Evidence is also produced to show that the discharging power of two negative ions of the same valency is the same. Current observations on the coagulation of the colloids in each case showed that the particles coagulate more and more freely as the charge gets smaller and smaller.

Arc and Spark Phenomena in the Secondary of a High Potential Transformer: E. S. JOHONNOTT, Rose Polytechnic Institute. (Read by title.)

The Upper Inversion in the Atmosphere: W. J. HUMPHREYS, Mt. Weather Observatory, Md.

We have been accustomed to think of the atmosphere as growing steadily colder to nearly or quite absolute zero with increase in elevation, but hundreds of records obtained in many parts of the world by the aid of free balloons show that this assumption is very wide of the truth.

These records tell us, among other things:

(*a*) That through the first ten thousand feet next the earth the temperature changes irregularly, and often has one or more layers warmer than the regions immediately below or above them.

(*b*) That roughly between ten thousand and forty thousand feet above the surface of the earth the temperature falls tolerably regularly, approximately at the rate of 0°.7 C. per hundred meters, or 0°.4 F. per hundred feet.

(*c*) That somewhere in the neighborhood of forty thousand feet elevation the temperature quits falling, usually abruptly, and commonly increases slowly from this level up to the greatest elevation yet reached, about 26.6 kilometers (16½ miles).

The place where the temperature quits falling and begins to rise is called the inversion level. Its elevation and its temperature both change with seasons, with latitude, and with storm conditions.

This inversion and all the other phenomena connected with the temperature gradients of the atmosphere appear to be satisfactorily accounted for by the known composition of the atmosphere and the laws of radiation and absorption.

The paper in full appears in the *Astrophysical Journal*, January, 1909.

Some Results in Solar Magnetism: W. J. HUMPHREYS, Mt. Weather Observatory, Md.

The splendid work of Hale and others at Mount Wilson has led to the conclusions: (*a*) that sun spots are cooler than the surrounding regions; (*b*) that they are centers of violent cyclones; (*c*) that they are accompanied by magnetic fields of great intensity.

Assuming the effective temperature of the sun to be 6,000° C., simple convection can reduce the temperature of solar vapor to about 5,000° C., so that lower temperatures, if such exist, must be due to some such explosive action as Fox has shown to accompany the spots.

The observed tangential velocity of 100 kilometers per second can not be accounted for as the result of simple differences in barometric gradients.

The observed magnetic field can not be due to a whirling surface charge, since a charge sufficient to produce it would cause disruptive radial forces. A volume charge, however, of the negative sign, analogous to that which somehow exists in the earth's atmosphere might lead to the observed effects.

The magnetic fields of the sun spots, however produced, can not extend in measurable amounts to the earth, and therefore our magnetic storms are still without a definitely assignable cause.

The full paper appears in *Terrestrial Magnetism and Atmospheric Electricity*, December, 1908.

Note on Thermoluminescence: ELIZABETH R. LAIRD, Mt. Holyoke College.

Theory suggests that the change producing luminescence goes on very slowly at ordinary temperatures in thermoluminescent salts and is merely accelerated by raising the temperature. An additive method of obtaining the effect of thermoluminescence should therefore show its existence at room temperatures.

This was tested by wrapping up photographic plates for different periods of time with sensitive film toward a thermoluminescent salt and developing later, at the same time heating the salt to observe the remaining effect.

The salts used were solid salt solution of calcium sulphate and magnesium sulphate, the same with an undetermined admixture and calcium sulphide which had been kept in the dark some time after all visible luminescence had ceased.

The results showed that the photographic plate was unaffected in each case, with exposures varying from two weeks to two months, according to the salt used and the amount of its previous exposure to light. Where the effect was uneven the greater effect corresponded to the portions showing brighter thermoluminescence. Control plates used with salt that had not been exposed to light after heating showed no effect in the same time.

These experiments indicate that there is a slow change in thermoluminescent salts, probably similar to that occurring at a higher temperature.

ALFRED D. COLE,
Secretary

THE AMERICAN PHYSIOLOGICAL SOCIETY

THE American Physiological Society met in the physiological laboratory of the Johns Hopkins University, December 28 to 31. Sessions for the reading of papers were held in the forenoons of December 29, 30, 31 and the afternoon of December 31. Demonstrations were given in the afternoon. Seventy papers and demonstrations were presented.

A joint session with the American Society of Biological Chemists was held December 29. On the afternoon of the twenty-ninth the society met with Section K to hear the address of the retiring